WTCI-16-P

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M E M O R A N D U M

TO: K. King

FROM: R. Greenberg

DATE: October 23, 1991

SUBJECT: **CONCEPT STUDY – VENTING OF STAIRWAYS A B & C IN WTC TOWERS 1 & 2**

COPY TO: A. Brociner, P. Sweeney, S. Wiener

In accordance with your request, attached please find the subject study. The conclusions are as follows.

Although stairway venting is a code requirement it is our interpretation that stair venting serves as an after the fact housekeeping smoke purge function rather than one of life safety for the following reasons.

- Fully sprinklered buildings minimize smoke conditions in stairways during a fire condition. For the purpose of the subject study, as per your direction, the WTC facility is treated as a fully sprinklered building since it is nearing completion of its full sprinklerization program.

- During a fire condition the stairway venting system could not operate simultaneously with the primary existing smoke purge system. Therefore the stairway venting system would mostly operate as an after the fact housekeeping function.

The proposed concept as indicated is SK-2 for the stairway venting system consists of supply fans at the 7th floor MER's and exhaust fans with motorized dampers in conjunction with a fusible link at the 108 MER's.

The design was premised upon removing existing doors within the stairway as per your direction. However to date there appears to be no clear resolution between the Arch. and Q.A. groups on this issue.

Order of magnitude construction cost estimates for both towers for the proposed concept design is approximately 1.3 million.

Project implementation is approximately 2.0 years for preliminary/final design and construction.

Next Steps

It is recommended that engineering retain a Consultant with stair venting expertise to provide a second opinion concerning our interpretation of the life safety and housekeeping issues.

Preliminary design is required to develop routing of make-up air ducts at 7th floor and exhaust air ducts at 107th and 108th floors so as to minimize disturbance to existing base building services and to existing tenant spaces.

If there are any questions, or points requiring further clarification, please contact Bob Greenberg at 435-8868.

Bob

Robert Greenberg

STAIR VENTING CONCEPT STUDY

FOR STAIRS A, B, & C OF

WORLD TRADE CENTER TOWERS 1 & 2

PREPARED BY
PORT AUTHORITY ENGINEERING DEPT.

OCTOBER 1991

Introduction

In accordance with your request, an evaluation and conceptual design was developed to comply with the NYC Building Code requirements for stair venting (Section 27-375 subdivision i(4) and Section 27-344 subdivision d) for Stairs A, B, and C, serving the entire above grade portion of WTC Towers 1 & 2. (See Appendix A for Code excerpts)

Interpretation of Code

It is the Engineering Department's interpretation that safe and practical implementation of the code requirements serve only as a housekeeping function and not for building life safety purposes, for the following reasons.

1) The WTC facility is nearing completion of its full sprinklerization program and is therefore exempted [by Code Par. 27-253] from stair pressurization requirements. The code implies that fires in sprinklered buildings would cause only minimal smoke and heat conditions in exiting stair shafts. NFPA 92A paragraph 1-7 supports this interpretation. Thus, stair shaft vents which are required by Code to be either permanently open to the outdoors or automatically openable when stair temperature reaches 160°F. are considered of value only for fires originating within stairways, which is a very improbable scenario. Fires originating within the stairway are a localized problem and not an overall building life safety issue.

2) During a fire condition the existing smoke purge mode of operation of WTC HVAC systems will pressurize the central core area while maintaining a negative pressure in the exterior areas by exhausting from tenant spaces. This minimizes smoke migration to the stair shafts which are located within the core area.

3) With the exception of a fire originating in the stair shaft, it would be unsafe to activate a stair shaft exhaust system during a fire condition because such activation would undermine the existing smoke purge system by reducing core area pressurization, thereby drawing smoke into the stairway.

4) The stair shaft exhaust system should only be activated after fire and smoke conditions have been controlled and life safety has been secured. Essentially after the fact stairway exhaust systems would be relegated to a useful housekeeping function of purging minimal amounts of residual stairway smoke.

Conclusion

If the WTC Dept. wishes to exercise its prerogative to implement a housekeeping function to meet the letter of the code, Engineering offers the following concept design for a stair venting system as described hereafter.

Basis of Conceptual Design

I) General

The proposed stairway venting concept design calls for installing make-up and exhaust air fans, as indicated in sketch SK-2, even though it is not a strict code requirement for the following reasons:

a) Smoke in the stair shaft is expected to be at or near ambient temperatures due to sprinkler operation thereby reducing stack effect benefits.

b) Severe and unpredictable wind conditions unique to the WTC 108th floor MER's requires mechanical exhaust.

The fans would be remotely controlled by authorized personnel from a command center with interlocks between make-up and exhaust fans, between fans and their related dampers, and interlocks with existing smoke purge system.

II - Existing Stair Configuration & Modification

Tower stairs A, B and C contain offsets at various floors.

The horizontal portions of the stairs are isolated from the vertical portions by normally closed doors which were part of the original design to comply with an old code requirement limiting lengths of stair landings. This code requirement is no longer in effect. Horizontal offsets can be an integral part of the stairwell so long as fire rated construction is continuous throughout, which is the case.

The conceptual design calls for removal of these doors. [See sketch SK-1] This allows stair shafts A,B, & C to be vented by a system delivering make-up air by mechanical means at the 7th Fl. and exhausting at the top of each stair shaft as shown in sketch SK-2.

III - Air Quantity

Generally, smoke purge systems are required by code to maintain either 1 cfm per $ft.^2$ or 6 air changes per hour for fully sprinklered buildings.

Note that make-up air could be supplied by manually opening the proper stair door using authorized facility personnel. This would eliminate the need for make-up air fans. However potential for short circuiting is increased if the wrong stairway doors are opened, thereby decreasing the systems ability to purge residual smoke in the stairways.

For stairs A, B and C, which are about 1400 feet long and have gross shaft areas of about 120 ft.^{2}, 200 ft.^{2}, and 120 ft.^{2} respectively the minimum required cfm for each full stair smoke purge is as follows:

Stair A - 16,800 cfm

Stair B - 28,000 cfm

Stair C - 16,800 cfm

If the present compartmentation is maintained by leaving existing doors in place, air quantities shown above would approximately triple, as would construction cost.

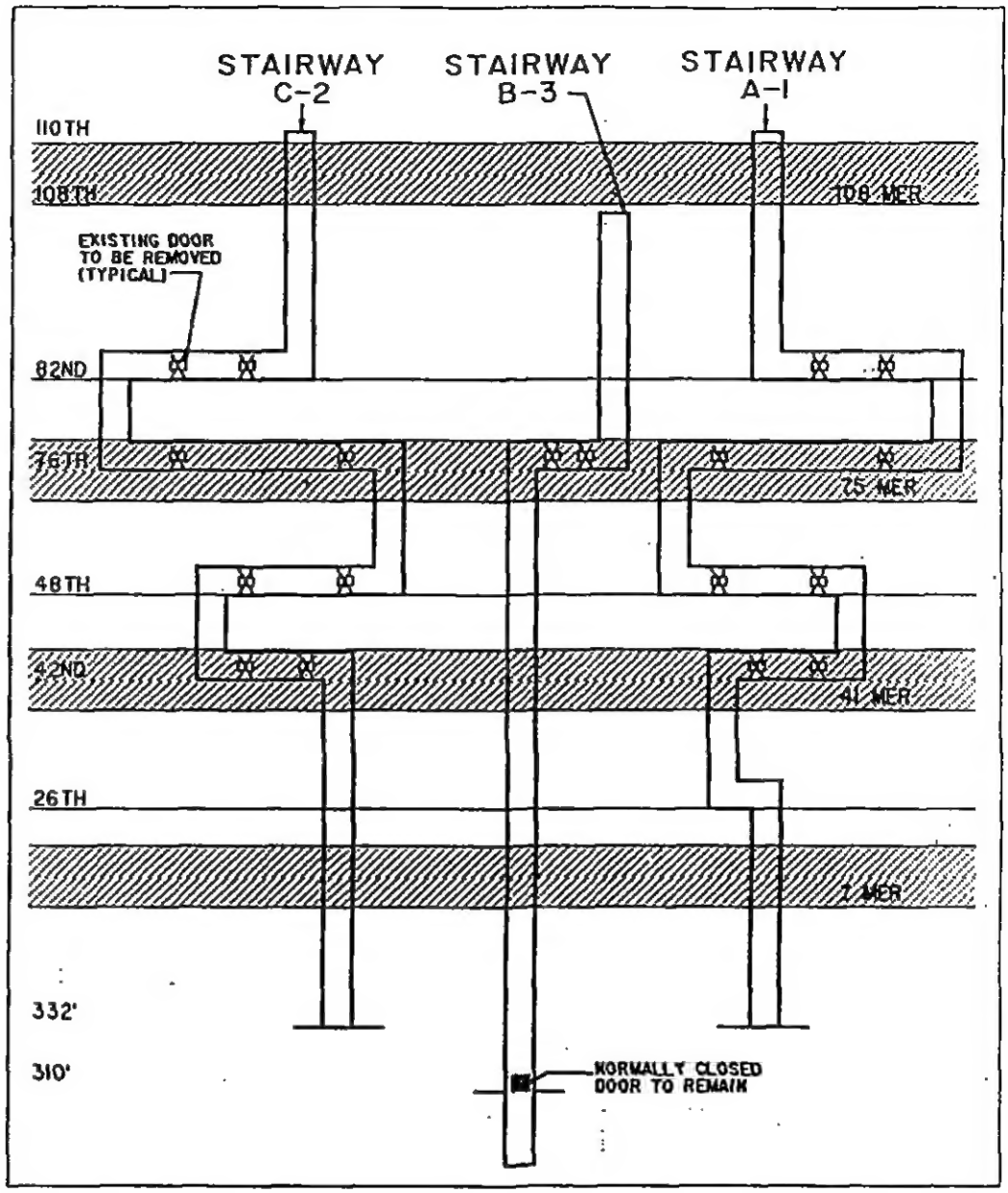
The resulting velocity in the cross-section of the stair shaft will be 140 fpm (approximately 1.6 mph).

Construction Cost Estimate

An order of magnitude cost estimate for both towers to implement the proposed stair shaft vent concept presented in SK-2 is approximately $1.3 million in 1991 dollars. The estimate does not include any cost for tenant interruptions, relocations, and asbestos removal.

Project Implementation Schedule

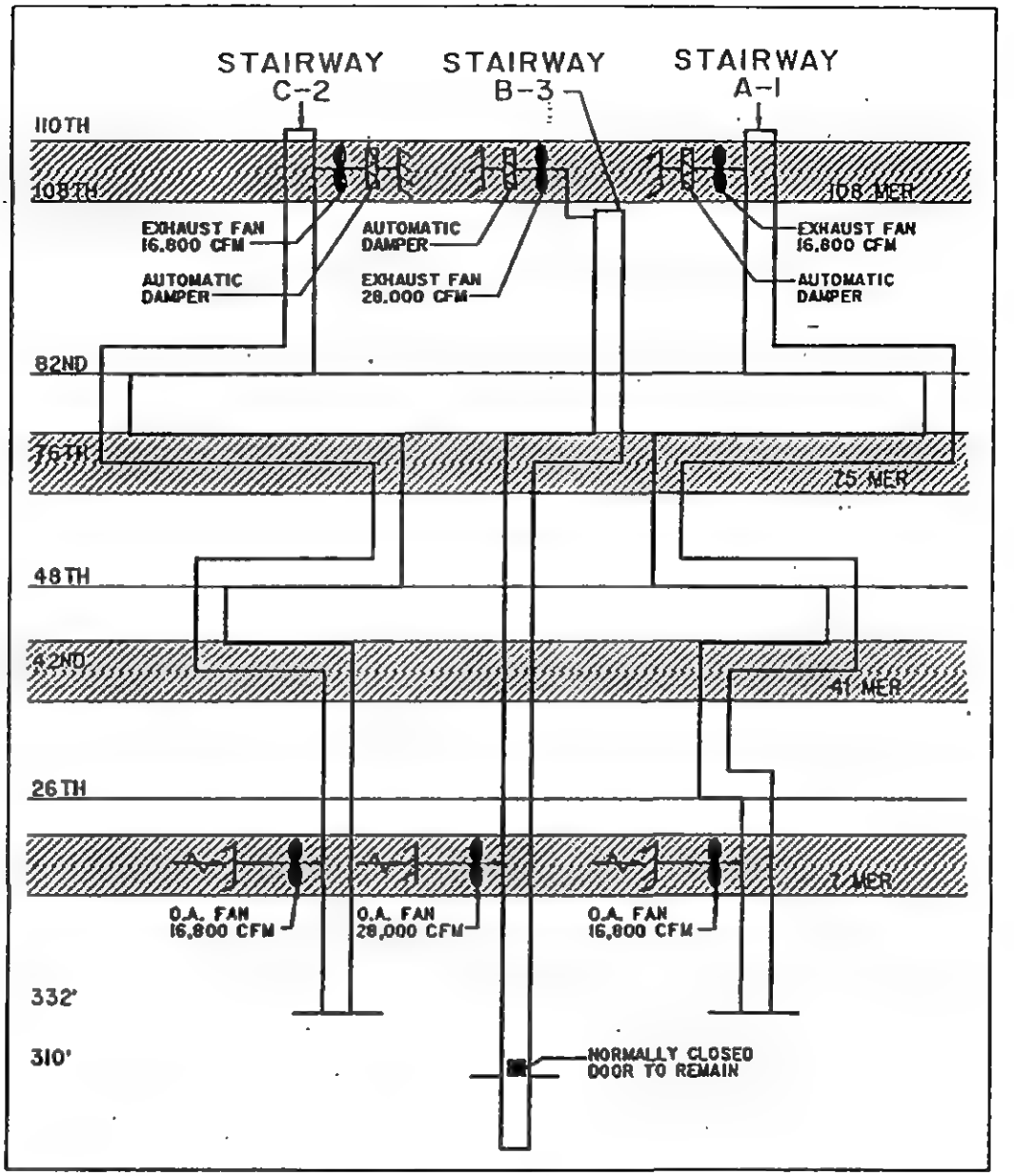
It is estimated that implementation of the proposed concept would require approximately 2 years for preliminary/final design and construction. Preliminary design is required to develop routing of make-up air ducts at 7th floor, and exhaust air ducts at 107th and 108th floors so as to minimize disturbance to existing building services and to existing 107th floor tenant spaces.



WORLD TRADE CENTER TOWERS 1 AND 2
TOWER 2 SHOWN
TOWER 1 SIMILAR

REMOVAL OF EXISTING DOORS

SK-1



AUTOMATIC DAMPER OPERATION:

THE NORMALLY CLOSED DAMPER SHALL OPEN AS FOLLOWS:

A). VIA FUSIBLE LINK AT 160 °F

OR

B). VIA REMOTE CONTROL BY AUTHORIZED PERSONNEL, INTERLOCKED TO START O.A. FAN AND EXHAUST FAN.

WORLD TRADE CENTER TOWERS 1 AND 2
TOWER 2 SHOWN
TOWER 1 SIMILAR

PROPOSED STAIR VENTING SYSTEM CONCEPT

SK-2

APPENDIX A

CODE SECTIONS

material and is closed off by close-fitting metal escutcheons on both sides of the construction; and provided further that the aggregate net area of such openings does not exceed twenty-five square inches in any one hundred square feet of wall or floor area (excluding the areas of openings for sleeves which are firestopped in conformance with this section and section 27-345).

(c) **Openings for passage of pipe and ducts** whose aggregate net area exceeds twenty-five square inches in any one hundred square feet of wall or floor area (excluding opening for sleeves which are firestopped in conformance with this section and section 27-345) may pierce constructions required to have a fire-resistance rating only when the type of construction to be used has been tested with such types of facilities installed in place and the proportionate area of openings of such facilities to be installed in the construction does not exceed the proportionate area of openings in the assembly tested, and provided no opening is larger than that in the assembly tested. Protection of such openings shall be the same as provided in the test. All openings through hollow fire rated construction shall be sleeved with sheet metal least No. 14 U.S. std. gage thick.

§ 27-344*(C26-504.6)* **Shafts.** The requirements of this section shall apply to all shafts, except that floor openings accommodating a slide pole in a fire house and openings other than for ventilation, chimneys or gas vents in buildings three stories or less in height classified in occupancy group J-3 shall be exempt from these requirements, and except as more restrictive requirements may be specified for chimneys and gas vents in subchapter fifteen of this chapter, stairway enclosures in subchapter six, duct enclosures in subchapter thirteen, elevator, escalator, and dumbwaiter enclosures in subchapter eighteen of this chapter, and except as permitted in reference standard RS 5-18.

(a) **Construction.** Shafts shall be enclosed with materials having at least fire-resistance rating required by table 3-4. A shaft that serves the topmost story of a building shall extend through the roof at least thirty-six inches above any combustible roof construction. Where the roof construction is of noncombustible materials, the shaft shall extend through any concealed space within the roof construction and may terminate at the underside of the roof deck. Pipes and ducts penetrating shaft construction shall comply with the requirements of section 27-343 of this article.

(b) **Combustible Contents.** Shafts shall be kept free of bookstacks or other combustible contents except for stair construction as permitted under subchapter six of this chapter, duct and pipe coverings as permitted under subchapters thirteen and sixteen, and elevator car enclosures as permitted under subchapter eighteen of this chapter.

(c) **Openings in shafts.** All shaft openings below the top terminus shall be provided with opening protectives that comply with section 27-329 of this subchapter and table 5-3. In shafts that contain only one opening below the roof terminus, no opening protective need be provided. Openings in elevator and dumbwaiter shafts shall comply only with the requirements of subchapter eighteen of this chapter. Where a window is located in a shaft wall that is an exterior wall and is ten stories or less above grade or three stories or less above a roof, it shall be protected against entrance by a permanently secured grille consisting of 5/8 in. dia. bars, 10 in. o. c. vertically, or by a stationary metal sash window having 1/8 in. thick solid section steel muntins, 8 in. o. c. one way. This protection shall not be required in stair shafts where there is a stair landing or platform not more than three feet directly below the window sill.

(d) **Smoke venting of closed shafts.** All closed shafts having an area exceeding four square feet, other than elevator or dumbwaiter shafts, shall be provided with a smoke vent having an area of at least three and one-half percent of the maximum shaft area at any floor, but in no event less than one-half square foot. Elevator and dumbwaiter shaft vents shall comply with the requirements of subchapter eighteen of this chapter. Smoke vents may be windows, louvers, skylights, vent ducts, or similar devices. Vent ducts shall be enclosed by construction having the same fire resistance rating as required for the shaft enclosure. Such vent ducts shall extend vertically, diagonally, or horizontally as provided below.

(1) Through any roof of the building provided the vent opening is at least ten feet from any window, door, outside stairway, or interior lot line. This dimension may be reduced to five feet if the vent duct is extended up to at at least the level of the top of the window or door. A vent that is required to extend above a roof shall extend at least eight inches above a roof assembly constructed of noncombustible materials, and at least thirty-six inches above a roof assembly constructedof combustible materials that are within a horizontal distance of ten feet.

(2) Through an exterior wall of the building, provided there are no openings in the wall within a distance of thirty feet vertically above the vent opening, and within five feet either side of the vent opening. When a side of a shaft is an exterior wall or a wall of a roof bulkhead, the required vent may be a louver or window. Any window or louver located in a shaft wall above a roof constructed of combustible materials shall have its sill at least thirty-six inches above the roof.

(e) **Terminus of shaft vents.** Of the total required vent area for shafts, at least one-third shall be clear opening to the outdoors, either in the form of fixed louvers, ridge vents, or hooded or goosenecked openings. In lieu thereof, skylights or trap doors may be used if constructed and arranged to open automatically by fusible link or other mechanical device when subjected to a temperature of one hundred sixty degrees Fahrenheit or to a rapid rise in temperature at a rate of fifteen to twenty degrees Fahrenheit per minute. The remaining portion of the required vent area may be a window or skylight glazed with plain glass not more than one-eighth inch thick or slow burning plastic.

(f) **Machine rooms.** Any compartment containing machinery that communicates with a shaft enclosure shall comply with all requirements for shafts. The required louver or glazing shall not be located in any door leading into such compartment.

§ 27-345*(C26-504.7)* **Firestopping.** Concealed spaces within partitions, walls, floors, roofs, stairs, furring, pipe spaces, column enclosures, etc. that would permit passage of flame, smoke, fumes, or hot gases from one floor to another floor or roof space, or from one concealed area to another, shall be firestopped to form an effective draft barrier, or shall be filled with noncombustible material in accordance with the requirements of this section. Firestopping shall not be required where a concealed space is sprinklered in accordance with the construction provisions of subchapter seventeen of this chapter, or is constructed as a shaft.

(a) **Firestopping materials.** In buildings of construction group I, firestopping or fill shall be of noncombustible material that can be shaped, fitted, and permanently secured in position. In buildings of construction group II, firestopping may be of combustible material consisting of wood not less than two inches nominal thickness with tight joints, two layers of one inch nominal thickness assembled so that there are no through joints or of one-half inch exterior type plywood with joints backed, except that noncombustible firestopping shall be used in concealed spaces of fire divisions and where in contact with fireplaces, flues, and chimneys. Noncombustible firestopping may be masonry set in mortar, concrete, three-quarter inch thick mortar or plaster on noncombustible lath, plasterboard at least three-eighths of an inch thick, fire-rated wallboard at least five-eighths of an inch thick, sheet metal at least No. 14 U.S. std. gage thick, solid web metal structural members, asbestos-cement board at least one-quarter of an inch thick, or equivalent rigid noncombustible material. Mineral, slag, or rockwool may be used for firestopping when compacted to a density of at least three and one-half pounds per cubic foot into a confined space of least dimension not more than one-third its second dimension.

(1) The performance of through-penetration fire stops shall be measured and specified according to reference standard RS 5-19.

(2) The commissioner may accept reference standard RS 5-19 test data results from an independent laboratory acceptable to the commissioner pursuant to subdivision (c) of section 27-131, when such data is submitted by a registered architect or

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b. Any room classified in occupancy group H, or any room leading therefrom as defined in note b of table 5-4.

c. Any room in which the net floor area per occupant is twenty square feet or less, or any room leading therefrom as defined in note b of table 5-4.

d. Luminous ceilings constructed elsewhere than in the spaces listed in subparagraphs a, b, and c above shall be exempt from the provisions of section 27-348 of this article, provided that:

1. The panels of such ceilings are of slow-burning plastic;

2. The panels are installed above or below sprinklers that are constructed in accordance with the provisions of subchapter seventeen of this chapter;

3. No individual plastic panel exceeds ten feet in maximum dimension. Where installed below sprinkler heads, the plastic shall be a material that will fall from its mounting at a temperature at least fifteen degrees lower than the temperature at which the sprinkler heads are designed to operate or are constructed of open material which will not impede the flow of water from the sprinkler heads. Luminous ceilings shall be installed so as to provide ready access to all heads and valves.

(b) **Suspension of new ceilings below existing suspended ceilings.** *In construction group* I a new ceiling may be suspended below not more than one existing suspended ceiling and shall be supported directly from the ceiling carrying channels adjacent to the hangers. In construction group II, an existing suspended ceiling shall be completely removed before a new ceiling may be suspended.

§ 27-351*(C26-504.13)* **Finish flooring and floor coverings.** Finish flooring and floor coverings shall comply with the following: (a) In buildings or spaces classified in occupancy group A and in all exits except those in buildings of construction group II-E, finish flooring shall be of noncombustible material and except as otherwise provided for stairs in subdivision (h) of section 27-375 of article five of subchapter six of this chapter.

(b) **Flooring in buildings or spaces of construction group I.** Except as provided in subdivision (a) of this section combustible finish flooring may be used in buildings or spaces of construction group I when cemented directly to the top surface of noncombustible floor construction, or attached to combustible or noncombustible sleepers. When attached to sleepers, the space between the noncombustible floor construction and the bottom of flooring shall be solidly filled with noncombustible material to within one-quarter inch of the flooring, or the space between the sleepers under the flooring shall be firestopped into areas of not more than twenty square feet, and provided further that no open spaces shall extend under or through fire divisions or through fire separations. Combustible insulating or sound absorbing boards not more than one-half inch thick and having a flame-spread rating not greater than class C may be used when attached directly to noncombustible floor construction and covered with finish flooring.

(c) **Flooring in buildings or spaces of construction group II.** Except as provided in subdivision (a) of this section, finish flooring in buildings or spaces of construction group II may be of combustible material.

(d) **Floor coverings.**

(1) Exits. Where exits are required under any provision of this code, carpets and carpet assemblies shall not be installed in such exits, except that wool carpeting may be installed in lobby areas, exit passageways and convenience stairs.

(2) Flammability requirements. The requirements of this subdivision shall apply to carpets and carpet assemblies only when used as a floor covering (for requirements pertaining to carpets and carpet assemblies used as interior finishes, see section 27-348 of this article). For purposes of this subdivision, carpeting assemblies shall include the carpet, its underlay, and adhesives which when tested as a composite shall be representative of the proposed installation.

a. Pill test. All carpets and underlayments shall pass a methanine pill test in accordance with the requirements of reference standard RS 5-20.

b. Critical radiant flux test. Carpets and carpet assemblies shall be tested by the method for critical radiant flux in accordance with the requirements of reference standard RS 5-20. The time frame for such test shall be at least a fifteen minute exposure.

1. Carpets and carpet assemblies representative of the actual installation on floors of corridors, shall have a minimum critical radiant flux of 0.5 watts per square centimeter (W/cm^2).

2. Carpets and carpet assemblies representative of the actual installation on floors of general areas shall have a minimum critical radiant flux of 0.4 W/cm^2.

c. Smoke developed ratings. Carpets and carpet assemblies representative of the actual installation on floors of corridors or general areas shall be tested for smoke developed ratings in accordance with the requirements of reference standard RS 5-20. The smoke developed ratings in either the flaming or no-flaming mode shall not exceed three hundred within the first four minutes of the test.

d. The manufacturer of the carpets and carpet assemblies shall submit a certificate from an independent laboratory acceptable to the commissioner pursuant to section 27-131, showing the complete test data results, prior to final acceptance. The certification shall state that the material is treated for fire resistance and shall indicate the service life of the treatment or that the material is inherently fire resistant by virtue of its construction, chemical properties and/or composition. Materials which are not inherently fire resistant may be used only when the certified fire resistant service life exceeds that of the planned service life of the carpets and carpet assemblies with consideration being given to cleaning, traffic, and other conditions of use which may affect the treatment.

§ 27-352*(C26-504.14)* **Fireplaces.**
(Repealed by Local Law 80/1989.)

§ 27-353*(C26-504.15)* **Smoke and heat venting.** (a) Where the floor area of a one-story building classified in occupancy group A, B-1, or D-1 is greater in depth than one hundred feet from a frontage space, that portion beyond one hundred feet shall be provided with roof vents and smoke curtains complying with the requirements of reference standard RS 5-11. Where the effective area of vents are glazed with plain glass or plastic not thicker than one-eighth inch, they need not be provided with automatic opening devices.

(b) Buildings classified in occupancy group E, one hundred feet or more in height, having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, shall be provided with at least one smoke shaft by means of which smoke and heat shall be mechanically vented to the outdoors as provided in reference standard RS 5-17.

Buildings that are sprinklered throughout shall be exempt from the smoke shaft requirements.

(c) Existing office buildings, one hundred feet or more in height, having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, shall be provided with at least one smoke shaft by means of which smoke and heat shall be mechanically vented to the outdoors as provided in reference standard RS 5-17, or in lieu of such smoke shaft or shafts, all interior enclosed stairs other than a fire tower or access stairs may be provided with a system of pressurization for fire emergency use.

Such pressurization shall be provided by means of a system or systems as provided in reference standard RS 5-18. Such buildings shall comply with the smoke and heat venting requirements herein on or before September thirteenth, nineteen hundred eighty-two. Complete plans showing such compliance shall be filed with, and a permit secured from, the commissioner on or before September thirteenth, nineteen hundred eighty.

Existing buildings that are sprinklered throughout shall be exempt from the smoke shaft and stair pressurization requirements.

An existing building which is to be sprinklered throughout shall be exempt from the smoke shaft and stair pressurization requirements under the following conditions:

(1) the installation proceeds in conformance with a schedule acceptable to the commissioner, *setting forth the sequence and corresponding time for installation in the*

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various locations. On or before September thirteenth, nineteen hundred eighty such a schedule, as well as complete plans of the installation, shall be filed with, and a permit secured from, the commissioner for the phase of the work to be done as required by paragraph two of this subdivision.

(2) at least one-third of the total floor area of the building, including but not limited to the entrance lobby, corridors and elevator landing areas, is sprinklered on or before December thirteenth, nineteen hundred eighty-one.

(3) at least two-thirds of the total floor area of the building is sprinklered on or before December thirteenth, nineteen hundred eighty-two.

(4) the building is sprinklered throughout on or before December thirteenth, nineteen hundred eighty-three.

Where compliance with the time requirements of this subdivision would cause undue hardship, the commissioner, with the approval of the fire commissioner, may extend the time for compliance, in accordance with rules and regulations to be promulgated. Before such application for a time extension shall be considered all required applications and plans must be filed and approved, permits obtained and a good faith effort towards completion of the work shall have been made.

*§ 27-353.1 *(C26-504.16)* **Smoke protection for elevators and escalators.** (a) **Elevators.** In existing buildings classified in occupancy group J-1, at every floor above the main entrance floor, all passenger elevators shall open only into elevator vestibules, except for:

(1) Such existing buildings which contain spaces classified in occupancy group C or F and have an automatic sprinkler system protecting all spaces (except boiler rooms) not in occupancy group J-1 and all exits and corridors serving such spaces located on or below the lowest floor containing sleeping rooms as well as all storage closets no matter where located, except that storage closets less than seventy-five square feet may, in the alternative, be provided with smoke detectors which shall be of the central supervisory type connected to an approved central station; or

(2) Such existing buildings which contain no spaces in occupancy group C or F, and have either:

a. An automatic sprinkler system protecting all public areas and storage closets; or

b. An automatic sprinkler system protecting all sleeping rooms and storage closets.

c. Notwithstanding subparagraphs a and b of this paragraph, storage closets less than seventy-five square feet may be provided with smoke detectors of the central supervisory type connected to an approved central station.

d. Notwithstanding any other provision of this code, the sprinklers serving the storage closets may be connected with the domestic water supply.

(b) **Escalators.** In buildings and existing buildings classified in occupancy group J-1, fire protection for escalators shall be provided by any one of the following methods:

(1) Enclosure in accordance with sections 27-375 and 27-378 if escalator is used as an exit; or

(2) Automatic rolling shutters in accordance with reference standard RS 18-1; or

(3) Kiosks in accordance with reference standard RS 18-1; or

(4) Where the building section is fully protected by a supervised automatic sprinkler system and the escalator sprinklers are spaced to protect exposed sides of the escalator opening, a noncombustible heat apron constructed to bank heat around the sprinkler heads adjacent to the opening where the bottom edge of the

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(c) Unenclosed stairs in buildings classified in assembly occupancy group F may be permitted as provided in subchapter eight of this chapter.

(d) Stairs from floors or mezzanines may be unenclosed, with open or closed risers.

(e) In buildings classified in occupancy group J-2 occupied exclusively by not more than one family on each story without boarders, roomers or lodgers and not more than three stories in height, the enclosing construction may have a one hour fire-resistance rating which may be constructed of combustible material provided that the stair enclosure is protected with an automatic sprinkler system complying with the construction provisions of subchapter seventeen of this chapter.

(f) In buildings classified in occupancy group J-1 or J-2 not more than two stories in height of combustible construction group II, the enclosing construction may have a one hour fire-resistance rating which may be constructed of combustible material; however, where only one vertical exit is provided the stair enclosure shall be protected throughout with an automatic sprinkler system constructed in accordance with the provisions of subchapter seventeen of this chapter.

(g) Except as provided in subparagraphs (a), (e) and (f) of this paragraph, in all buildings or spaces classified in occupancy group J-1 or J-2, the enclosing construction shall be of masonry or an approved equivalent material having at least a two hour fire-resistant rating.

(2) Access stairs connecting not more than two stories which do not serve as a required exit may be constructed without an enclosure in buildings classified in other than occupancy group H-2. Such stairs shall be additional to and shall not obstruct or interfere with required exit facilities. When the first story below grade is served by an interior, unenclosed access stair, it shall be sprinklered in accordance with the construction provisions of subchapter seventeen of this chapter.

(3) The interior finish of interior stair enclosures shall be in accordance with the requirements of table 5-4.

(4) Stair enclosures shall be vented in accordance with the requirements for shafts in subdivision (d) of section 27-344 of article five of subchapter five of this chapter except that stair enclosures for buildings or spaces classified in occupancy group J-1 or J-2 shall be vented as follows:

a. In occupancy group J-2 buildings three stories in height and with not more than one dwelling unit per story or two stories in height with not more than two dwelling units per story, shall be provided with a skylight at least nine square feet in area, glazed with plain glass with a wire screen over and under and provided with fixed or movable ventilators having a minimum open area of forty square inches.

b. In occupancy group J-1 or J-2 buildings two stories in height with more than two dwelling units per story shall be provided with a skylight of at least twenty square feet in area, glazed with plain glass, with a wire screen over and under and provided with fixed or movable ventilators having a minimum open area of forty square inches.

c. In occupancy group J-1 buildings exceeding two stories in height and in occupancy group J-2 buildings three stories in height with more than one dwelling unit per story or exceeding three stories in height shall be provided with a skylight at least twenty square feet in area, glazed with plain glass with a wire screen over and under and provided with fixed or movable ventilators having a minimum open area of one hundred forty-four square inches. In lieu of the skylight and ventilators a window of equal area may be provided with fixed louvres having a minimum open area of one hundred forty-four square inches installed in or immediately adjacent to the window.

(5) When dwelling units are located over a space classified in occupancy group C or E on the street floor, they shall be provided with a separate enclosed interior stair, or with an exterior stair.

(j) **Openings and obstructions to stair enclosures.** No piping of any kind, with the exception of piping required or permitted in subchapter seventeen of this code, shall be permitted within a stair enclosure. No openings of any kind, other than windows, fire department access panels, exit doors and openings specifically authorized in reference standard RS 3-18 shall be permitted within a stair enclosure. Pipes required or permitted by such subchapter seventeen and protected in accordance therewith which do not reduce the required clearances of the enclosure may be permitted. Ducts protected in accordance with the requirements of subchapter thirteen of this chapter, which do not reduce the required clearances of the enclosure, may be permitted. In addition, in buildings in occupancy group J-2, which are three stories or less in height and occupied by not more than two families on each story, a door from an apartment may open directly into a stair, and the door may swing into the apartment.

(k) **Roof access.**

(1) Except as otherwise provided for in paragraphs two and three of this subdivision, in buildings or in building sections more than three stories or forty feet high with roofs having a slope of less than twenty degrees, access to the roof shall be provided by at least one interior stair, except that access to setback roof areas may be through a door or window opening to the roof. Interior stairs extending to roofs shall be enclosed in bulkheads of fire-resistant construction meeting the requirements of subchapter five of this chapter.

(2) In buildings or in building sections classified in occupancy group J-1 or J-2 more than two stories in height, except as otherwise provided for in paragraph three of this subdivision, with roofs having a slope of fifteen degrees or less all interior stairs, except those terminating at a level of a setback roof, shall extend to the roof and shall be enclosed in bulkheads of fire-resistive construction meeting the requirements of subchapter five of this chapter. Stairs terminating at the level of a setback shall provide access to the setback roof areas through a door except where the setback is less than four feet in width, measured from the inside of the parapet wall, and less than ten feet in length.

(3) In buildings or in building sections classified in occupancy group J-1 or J-2 two stories in height and in occupancy group J-2 three stories in height with not more than one dwelling unit per story with roofs having a slope of fifteen degrees or less, access to the roof shall be provided through a scuttle at least twenty-one inches in width and twenty-eight inches in length and shall comply with subdivision (c) of section 27-338 of article four of subchapter five of this chapter. Scuttles shall be located within each stair enclosure with a stationary iron ladder leading thereto.

(l) **Spiral stairs.** Spiral stairs may serve as access stairs between two floors or levels in accordance with the provisions of paragraph two of subdivision (i) of this section. Such stairs may not serve as required exits, except that unenclosed spiral stairs when built of noncombustible materials and having a tread length of at least thirty inches may serve as exits from mezzanines or balconies having an occupant load not exceeding twenty-five persons.

TABLE 6-4 MAXIMUM RISER HEIGHT AND MINIMUM TREAD WIDTH

Occupancy Group Classification of Building	*Maximum Riser Height (in.)*	*Minimum Tread[1] Width (in.)*
Residential J-3 (with closed risers) . . .	8 1/4	9 plus 1 1/4 nosing
Residential J-3 (with open risers)	8 1/4	9 plus 1/2 nosing
Residential J-2 (with only three dwelling units)	8 1/4	9 plus 1 1/4 nosing
Assembly F	7 1/2	9 1/2 plus nosing
Institutional H-2	7	10 plus nosing
All others[2]	7 3/4	9 1/2 plus nosing

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The design velocity through an open door should be sufficient to prevent smoke backflow during building evacuation. It should take into consideration the same variables as used in the selection of design pressure differences.

1-6.6 Number of Doors Open. The number of doors that may be open simultaneously should be considered. This number will depend largely on the building occupancy and the type of smoke control system. In some systems, doors will most likely be open for only short periods of time and the smoke leakage will be negligible.

1-7 Fire Suppression Systems. Automatic sprinkler and other suppression systems are an integral part of many fire protection designs and the reliability and efficiency of such systems in controlling building fires is well documented. It is important to recognize that the functions of both suppression and smoke control systems are important. Automatic suppression systems can extinguish a fire early in its growth, thereby eliminating additional smoke generation. On the other hand, well-designed smoke control systems can maintain a tenable environment along critical egress routes during the time it takes the fire suppression system or fire service personnel to achieve final extinguishment.

In addition to the fact that the systems perform different functions, it is important to consider the interaction between the smoke control and fire suppression systems. For example, in the case of a fully sprinklered building, pressure differences and airflows needed to control smoke movement may be less than in an unsprinklered building due to the likelihood that the maximum fire size will be significantly smaller than in an unsprinklered building.

A smoke control system can adversely affect the performance of gaseous agent (such as Halon, CO_2, or N_2) suppression systems when the systems are located in a common space. In the event that both systems are activated concurrently, the smoke control system may dilute the gaseous agent in the space. Since gaseous suppression systems commonly provide only one application of the agent, the potential arises for renewed growth of the fire. Gaseous suppression systems and smoke control systems cannot perform their intended functions simultaneously when they are located within the same space.

1-8 Testing. See 4-1.

1-9 Maintenance. See 4-4.

Chapter 2 Smoke Control Systems and Applicability

2-1 Introduction.

2-1.1 Purpose. This chapter discusses various types of smoke control systems currently available and reviews the advantages and disadvantages of each.

Determination of system objectives and performance criteria should be made prior to design or construction.

2-1.2 Dedicated and Nondedicated Systems.

2-1.2.1 Dedicated Systems.

(a) Dedicated smoke control systems are intended for the purpose of smoke control only. They are separate systems of air moving and distribution equipment that do not function under normal building operating conditions. Upon activation, these systems operate specifically to perform the smoke control function.

(b) Dedicated systems have the following advantages:

1. Modification of the controls during system maintenance is less likely to occur.

2. Operation and control is generally simpler.

3. They are less likely to be affected by the modification of other building systems.

(c) They have the following disadvantages:

1. Dedicated systems may be more costly.

2. Component failures may go uncorrected since they do not affect normal building operation.

3. Systems frequently require more building space.

2-1.2.2 Nondedicated Systems.

(a) Nondedicated systems are those that share components with some other system(s) such as the building HVAC system. Activation causes the system to change its mode of operation to achieve the smoke control objectives.

(b) Nondedicated systems have the following advantages:

1. Component failures of equipment required for normal building operation are less likely to remain uncorrected.

2. Equipment costs may be lower.

3. Additional space for smoke control equipment may not be necessary.

(c) They have the following disadvantages:

1. System control may become elaborate.

2. Inadvertent modification of controls affecting smoke control functionality is more likely to occur.

3. Other system modifications may interfere with smoke control system operation.

2-1.3 Basic System Types. Systems for controlling smoke movement in a building can generally be divided into two separate types: shaft protection and floor protection. Shaft protection can be further divided into stairtower pressurization systems and elevator hoistway systems. Floor protection encompasses several variations of zoned smoke control. Use of a particular system or combination of systems is dependent on building and fire code requirements, as well as specific occupancy and life safety requirements of the situation being considered.

2-1.4 Tenable Environment. A nonsmoke zone of a zoned smoke control system may be used as an area intended to protect occupants for the period of time needed for evacuation. The concept of area of tenable environment in which building occupants could wait out large fires has not achieved wide acceptance and design criteria have yet to be developed.